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(71) Applicant
National Supply Company (U.K.) Limited

(Incorporated in United Kingdom)

11/12 Pall Mall, London SW1Y 5LU

(72) Inventors
David James Armstrong
Cecil Claude Goonetilleke
Charles Sterling Johnson

(74) Agent and/or Address for Service
Marks & Clerk,
57-60 Lincoln's Inn Fields, London WC2A 3LS

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(54) Sealing between casing head and hanger

(57) A method and apparatus for providing a fluid-tight seal 28, 29 between a surface casing head or spool 2 and a casing hanger or tubing hanger 3, employ a seal ring 16 which is preliminarily inserted into the annular space between concentrically opposed surface portions 10, 11 of the respective well members, which seal ring is forced into the annular space to an extent that the seal ring plastically deforms and sealingly engages with said concentrically opposed surfaces 10, 11.

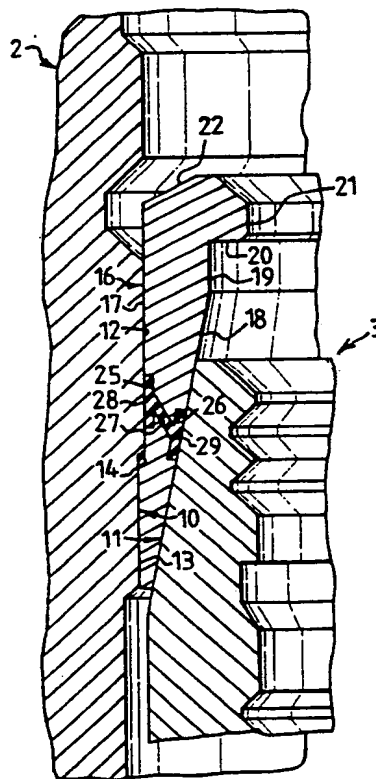


FIG. 6.

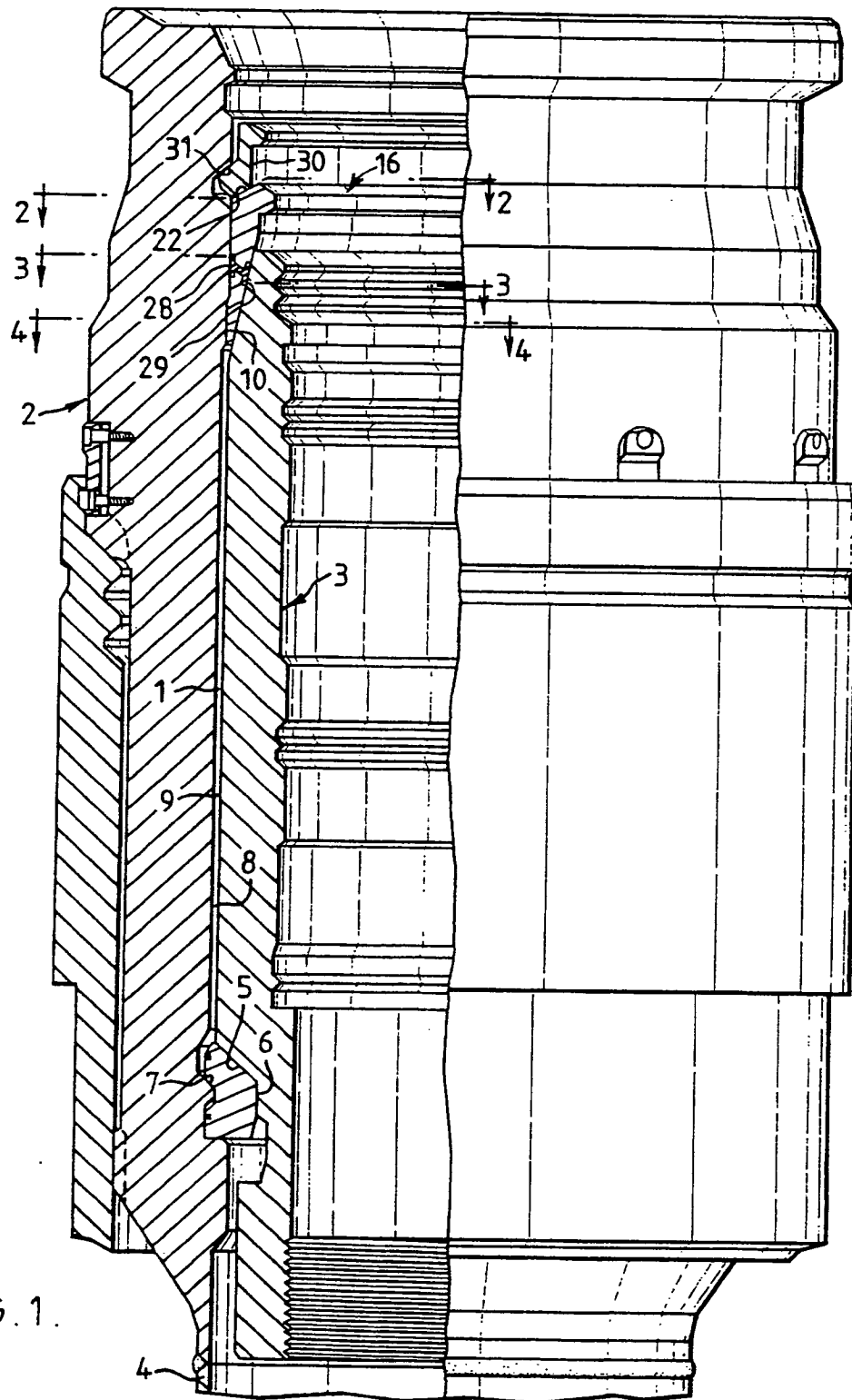


FIG. 1.

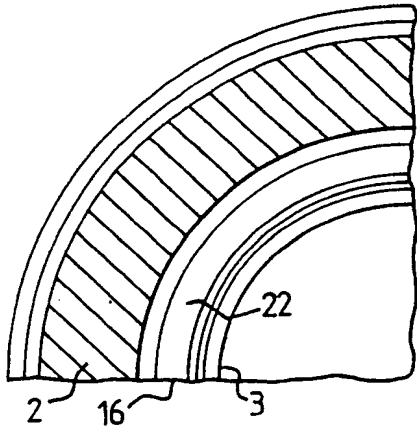


FIG. 2.

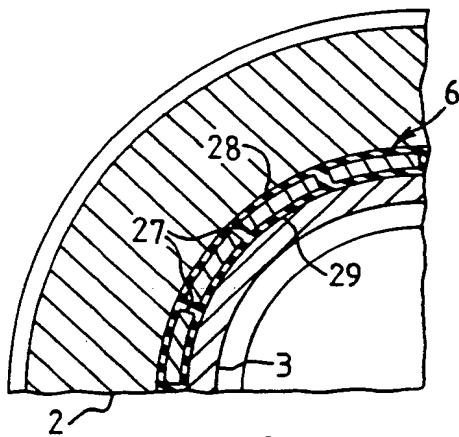


FIG. 3.

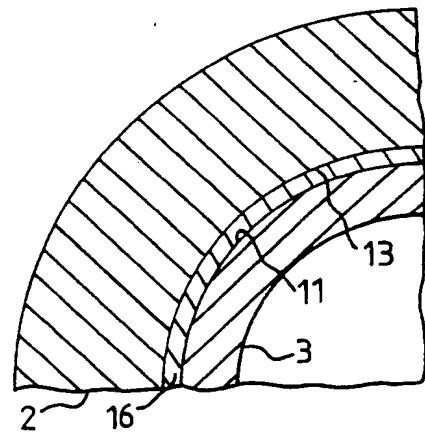


FIG. 4.

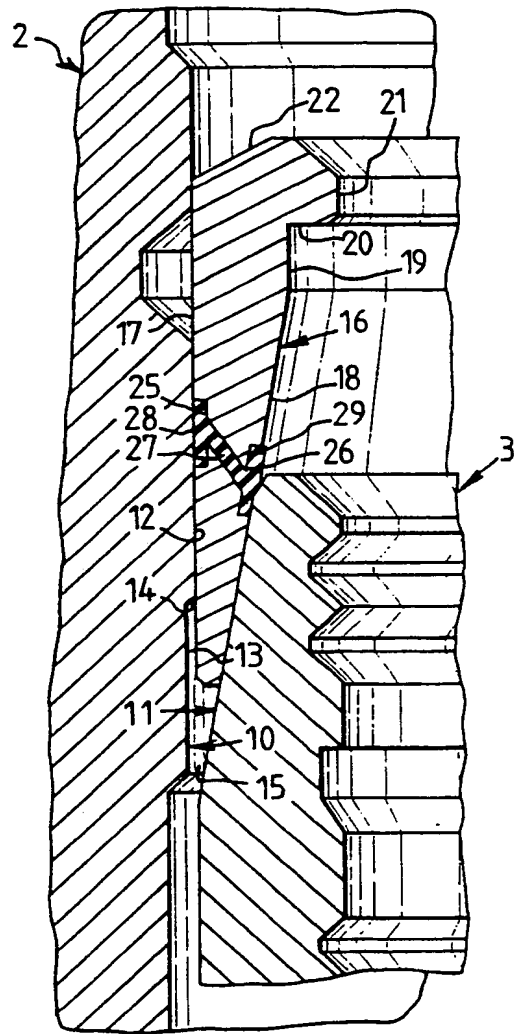


FIG. 5.

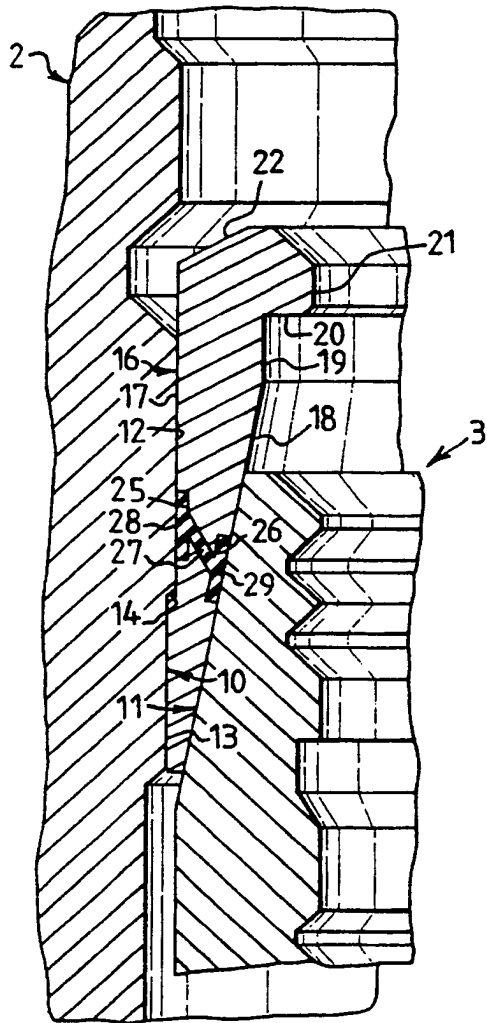


FIG. 6.

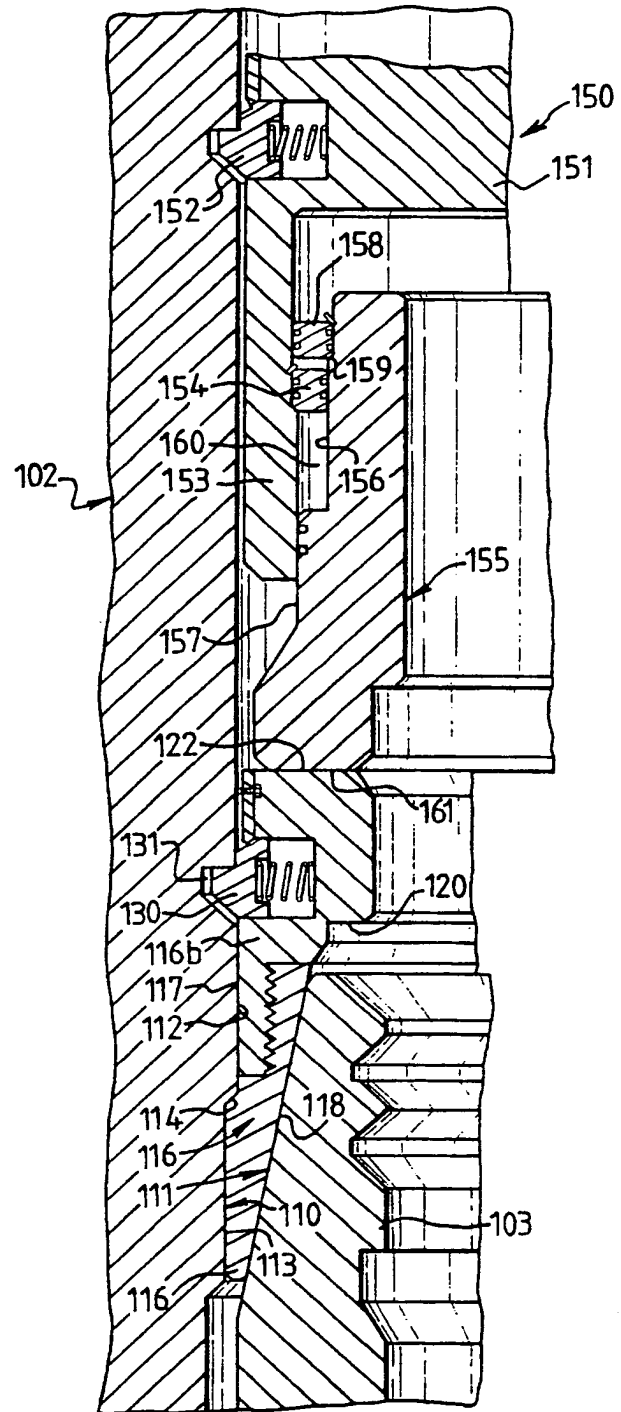


FIG. 7.

SPECIFICATION

Method and apparatus for sealing between two concentric members

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This invention relates to a method and apparatus for providing a fluid-tight seal between two concentric rigid well members in order to seal an annulus between the two members against large fluid pressures, said well members being respectively a surface casing head or spool and a casing hanger or being respectively a surface casing head or spool and a tubing hanger. The term 'surface' in this Specification denotes a land surface or the surface of a platform and is used to exclude any sub-sea apparatus or method.

US patent number 4 83,746 discloses a method and apparatus for providing a fluid tight seal between tubular members of a sub-sea well head. There is no suggestion in that patent however that the method and apparatus therein disclosed might have utility in respect of a surface casing head or spool. According to a first aspect of the present invention there is provided a method of providing a fluid-tight seal across an annulus between two concentric rigid well members in order to seal the annulus against large fluid pressures said well members being respectively a surface casing head or spool and a casing hanger or being a surface casing head or spool and a tubing hanger, said method comprising providing concentrically opposed surface portions on the rigid members,

at least one of said surface portions being generally frustoconical and tapering longitudinally of the rigid members, whereby said surface portions define therebetween an elongate annular space which tapers from a first larger radial width to a second smaller radial width, preliminarily inserting into said annular space a metal sealing ring which has a radial thickness which decreases axially of the ring.

the direction of preliminary insertion being such that the end portion of the ring which is of small radial thickness enters the portion of said annular space which is of larger width and proceeds toward the portion of said annular space of smaller radial width.

said concentrically opposed surface portions each including an elongate sealing surface which extends from the end of said annular space which is of small radial width toward the opposite end of said annular space, the length of said sealing surfaces being equal to a substantial portion of the axial length of the ring.

the relative radial widths of the ring and said elongate annular space being such that, as the ring is preliminarily inserted, the ring is stopped by engagement with at least one of said concentrically opposed surface portions when the leading end of the ring is still a substantial distance from the end of said elongate

annular space which is of smaller radial width,

at least the leading portion of the sealing ring being of a metal capable of significant plastic deformation, and

while restraining the two rigid members against axial displacement, applying to the end of the ring which is of larger radial thickness a force directed axially of the ring toward the end of smaller radial thickness and substantially uniformly distributed over the annular extent of the ring and thereby forcing the metal of at least the leading portion of the ring into a condition of plastic flow, with the ring then moving further into said annular space under the action of said force until a substantial portion of the length of the ring is in fluid-tight sealing engagement with both of said sealing surfaces.

According to a second aspect of the present invention there is provided surface well apparatus comprising a first rigid member having a bore including an inwardly facing annular surface portion, said first member comprising a surface casing head or spool,

a second rigid member extending within said bore and having an outer surface spaced inwardly from said bore wall to provide an annulus between the first and second rigid members, said outer surface including an outwardly facing surface portion spaced inwardly from and concentric with said inwardly facing surface portion said second member comprising a casing hanger or a tubing hanger,

at least one of said inwardly facing annular surface portion and said outwardly facing surface portion being generally frustoconical and tapering longitudinally of said rigid members, whereby said inwardly facing and outwardly facing surface portions combine to define an annular space which tapers from a first larger radial width to a second smaller radial width,

one of said inwardly facing and outwardly facing surface portions being interrupted by a transverse annular shoulder directed toward the end of said annular space which is of smaller radial width, the radial width of said annular space thus being increased adjacent said shoulder on the side of the shoulder toward the end of small radial width; and

a metal sealing ring disposed in said annular space and comprising

a first end portion at the end of said annular space which is of smaller radial width, said first end portion of the sealing ring substantially completely filling the corresponding portion of said annular space and having an outer surface in sealing engagement with the corresponding part of said inwardly facing surface portion of said first rigid member and an inner surface in sealing engagement with the corresponding part of said outwardly facing surface portion.

According to a third aspect of the present invention there is provided surface well apparatus

ratus comprising a rigidly supported surface casing head having an upright bore, said bore including

- 5 an upper right cylindrical wall portion,
 - a lower right cylindrical wall portion, and
 - a transverse annular downwardly facing shoulder joining said wall portions,
 - a second body disposed within said bore and including a frustoconical outer surface portion concentric with and spaced inwardly from said cylindrical wall portions, said outer surface portion tapering upwardly and inwardly, whereby said cylindrical wall portions and said outer surface portion combine to define an annular space which tapers from an upper end of larger radial width to a lower end of smaller radial width, said second body comprising a casing hanger or a tubing hanger,
 - said second body being rigidly supported
 - 20 against downward movement relative to said outer body,
 - a metal seal ring disposed between said cylindrical wall portions and said outer surface portion,
 - 25 the radial thickness of said seal ring decreasing from the upper end to the lower end of the ring, a lower portion of said seal ring being plastically deformed into direct metal-to-metal sealing engagement with both said cylindrical wall portions and said outer surface portion; and
 - 30 stop means engaged with said seal ring and said surface casing head to restrain said seal ring against upward movement relative to said surface casing head.
- It is surprising that the method and apparatus disclosed in US patent No 4583746 can be utilized in surface well apparatus and not merely in the subsea well apparatus described in that patent. Traditionally, surface well apparatus has been treated and considered quite separately from subsea well apparatus, since different problems are posed by the respective apparatus. Unexpected advantages accrue from the use of the method and apparatus of the present invention in relation to surface well apparatus, in particular, the apparatus of the present invention can be made considerably less heavy than comparable conventional surface well apparatus. In particularly advantageous embodiments, one of the concentrically opposed surface portions is interrupted by a transverse annular shoulder facing toward the end of the annular space which is of smaller radial width, providing in effect an annular recess into which the material of the seal ring flows during movement of the ring to its final position. Thus, with the one of the concentrically opposed surface portions carried by the inner rigid member being frustoconical and uninterrupted, the outer surface portion can include a first right cylindrical portion of smaller diameter joined by the transverse shoulder to a second right cylindrical portion of slightly larger diameter.

Though application of pressure to force the seal ring to its final position and cause the desired plastic deformation can be accomplished in various ways, it is advantageous to so construct the seal ring that it can act as a piston, and to apply fluid under pressure to generate the necessary force for moving the seal ring relative to concentric rigid members.

- 70 of the present invention will now be described, by way of example only, by reference to the accompanying drawings, in which:

Figure 1 is a view, partly in vertical cross section and partly in side elevation, of a surface well apparatus in which sealing across the annulus between a surface casing head body and casing hanger has been accomplished according to one embodiment of the invention,

- 85 Figures 2-4 are fragmentary cross-sectional views taken generally on lines 2-2, 3-3 and 4-4 respectively of Figure 1

Figure 5 is a fragmentary vertical cross-sectional view, enlarged with respect to Figure 1, showing the seal ring preliminarily inserted into the annular space between concentrically opposed surface portions of the surface casing body and casing hanger;

- 90 Figure 6 is a view similar to Figure 5 but showing the seal ring after reaching its final position, with plastic deformation having occurred, and

Figure 7 is a view similar to Figure 6 illustrating another embodiment in which the final stage of insertion of the seal ring is accomplished by a tool which is subsequently retrieved.

- 100 Figure 1 illustrates one embodiment of the invention as applied to sealing across the annulus 1 between a casing-head lower body 2 and a casing hanger 3. The apparatus shown is part of a surface well installation, with body 2 being secured to the upper end of an outer casing string 4, hanger 3 being supported on body 2 by a shoulder seated on an annular series of segments 6 seated on a shoulder 7 on body 2, and with annulus being in communication, in any suitable fashion, with the annulus between outer casing 4 and the casing (not shown) suspended from hanger 3.

Comparing figures 1 and 5, it will be seen that most of annulus 1 is defined by the main bore wall 8 of body 2 and the main outer surface 9 of hanger 3, both of which are right cylindrical, with surface 9 being spaced inwardly from and concentric with wall 8. However, at the upper end of hanger 3, annulus 1 is defined by two concentrically opposed surface portions 10 and Surface portion 10 is presented as part of the through bore of body 2 and includes an upper right cylindrical portion 12 and a lower right cylindrical portion 13, the latter being of slightly larger diameter than the former, portions 12 and 13 being joined by a transverse annular downwardly

facing shoulder 13. Surface portion 11 forms part of the outer surface of hanger 3 and has been landed on segments 6, surface portions 10 and 11 coact to define an annular space, indicated generally at 15, Figure 5, which tapers from a larger radial width, at the top of hanger 3, to a smaller radial width, at the lower end of right cylindrical portion 13.

With hanger 3 and body 2 related in the manner just described, a seal ring, indicated generally at 16, is preliminarily inserted downwardly into space 15, this operation being carried out conventionally by use of a handling tool and handling string (not shown). Seal ring 16 includes an integral main body of material capable of exhibiting significant plastic deformation, low carbon steel in the annealed or normalized state being a typical suitable material. In its initial form ring 16 has a right cylindrical outer surface 17 and an inner surface including a main frustoconical portion 18, tapering upwardly and inwardly at the same angle as surface portion 11 of hanger 3. The inner surface of the seal ring also includes a short right cylindrical portion 19 which extends upwardly from frustoconical portion 18 and joins a transverse annular downwardly directed shoulder 20. Shoulder 20 joins a short right cylindrical inner surface 21 which extends to the upper end face of the ring. The upper end face includes an outer frustoconical portion 22 which tapers upwardly and inwardly for a purpose hereinafter described.

In a location spaced from the lower end of the ring by a distance greater than the axial length of surface portion 13, outer surface 17 of the seal ring is interrupted by a transverse annular outwardly opening groove 25, Figure 5. In a location significantly below that of groove 25, frustoconical inner surface portion 18 is interrupted by a transverse annular outwardly opening groove 26. Grooves 25 and 26 are interconnected by a circularly spaced series of bores 27, Figures 3 and 5. Grooves 25 and 26 and bores 27 accommodate an integral body of elastomeric material constituting both an annular outer elastomeric seal body 28 and an inner annular elastomeric seal body 29, seal bodies 28, 29 being interconnected by elastic material within bores 27. With the elastomeric material in its relaxed and undistorted state, body 28 completely fills groove 25 and body 29 not only completely fills groove 26 but also projects slightly inwardly beyond surface portion 18. Accordingly, as ring 16 is preliminarily inserted downwardly into space 15, seal body 29 is progressively compressed as a result of engagement with surface portion 11. Such compression causes elastomeric material to flow outwardly through bores 27 to increase the volume of elastomeric material in groove 25. As a result, the elastomeric material preliminarily seals between the ring 16 and both surface portions 10 and 11 as soon as seal body

29 comes into good overlapping relation with the upper end of surface portion 11. Thus, preliminarily inserted as seen in figure 5, seal ring 16 is capable of action as a piston when pressure fluid is introduced within body 2.

As will be understood by those skilled in the well art, it is conventional to introduce pressure fluid into the casing head, after seals have been installed, in order to test the seal or seals. According to the invention this conventional practice is now employed to apply to the upper end portion of the preliminarily inserted seal ring 16 a large fluid pressure acting downwardly on and uniformly distributed over the annular extent of the ring. Since body 2 is rigidly supported, and hanger 3 is in turn rigidly supported on body 2 by shoulders 5 and 7 and segments 6, there can be no axial displacement of body 2 and hanger 3, and the effect of the applied fluid pressure is thus to force ring 16 downwardly further into annular space 15, in the manner seen by comparing Figures 5 and 6. At the start of such further displacement, the portion of ring 16 below elastomeric seal bodies 28, 29 substantially completely fills the annular space between surface portions 10 and 11 but does not seal therewith in acceptable fashion. However, since surface portions 10 and 11 converge downwardly, the remaining lower portion of annular space 15 is of inadequate width to accommodate the lower portion of ring 16 without deformation of the ring. Since the force applied downwardly on ring 16 by the pressure fluid is large in the context of the ability of the relatively ductile metal of ring 16 to resist plastic deformation, progressive movement of the ring downwardly into space 15 causes plastic deformation of the ring to such an extent that the ring completely fills the space between surface portions 10 and 11. Thus, metal of ring 16 reaches the final position seen in Figures 1 and 6, the lower portion of the ring has been forced into metal-to-metal sealing engagement not only with surface portion 11 but also with surface portion 13.

Installation of the seal can then be completed by installing a split locking ring 30, Figure 1, between end face portion 22 of ring 16 and the upper side wall 31 of a transverse annular inwardly opening locking groove provided in body 2, ring 16 thus being locked against upward movement relative to body 2. Installation of locking ring 30 is accomplished by use of a conventional handling tool and string (not shown). With the locking ring installed as shown in Figure 1, the combination of the locking ring and seal ring 16 serves to prevent upward movement of hanger 3 should excessive upwardly acting bore pressure occur.

Should need occur to retrieve seal ring 16, this can be accomplished by first removing locking ring 30 and then lowering a handling

tool equipped to engage shoulder 20 of the seal ring and applying an upward strain on ring 16 adequate to deform the portion of ring 16 which is below shoulder 14.

5 Seal ring 16 extends as a complete, unbroken annulus which, at time of installation, is in an initial undistorted state such that the diameter of outer surface 17 of the ring is slightly smaller than the diameter of part 12
10 of surface portion 10. Part 12 of surface portion 12 is the smallest diameter to be traversed by ring 16 during its trip down for installation and the possibility of scoring or otherwise damaging outer surface 17 of the
15 ring during the trip down is therefore minimized. Similarly the diameter of part 13 of surface portion 10 is significantly larger than that of part 12, so that part 13, constituting the outer sealing surface in the final assembly,
20 is protected from damage by tools and components passed through the casing head or spool before installation of the seal ring. It is to be noted that protection of the two active sealing surfaces 13 and 17 in this fashion is
25 possible only because of the plastic deformation of the seal ring during the final stage of installation.

It is particularly advantageous to form ring 16 of a low carbon steel in the annealed or
30 normalized condition. Thus, the steels identified by AISI numbers 1010, 1030 and 1040 are especially suitable Austenitic steels, such as those of the AISI 300 series, in the annealed state are also suitable. Non-ferrous al-
35 loys, particularly the copper-based and aluminum-based alloys, can also be employed. Non-metallic materials, such as a composite of polymers with a combination of fillers with or without reinforcing fibres may be suitable for
40 lower temperature and pressure applications. It will also be understood that only the portion of the seal ring which leads during insertion, such as the portion of ring 16 below the elastomeric seal bodies, need be of material
45 capable of plastic deformation.

The Embodiment of Figure 7

Figure 7 illustrates an embodiment of the invention in which final insertion of the seal
50 ring, to accomplish the necessary cold flow deformation, is accomplished by use of a tool rather than by introducing pressure fluid into the casing head or spool. Here, casing head body 102 and casing hanger 103 again combine to define the annulus 101 to be sealed.
55 The casing head body again has a through bore and the wall of the through bore includes surface portion 110 which is opposed to surface portion 111 of the casing hanger after
60 the hanger has been landed as described with reference to Figures 1-6. Surface portion 110 is identical to surface portion 10, Figures 1-6, and includes an upper right cylindrical part 112, a lower right cylindrical part 113 and a
65 transverse annular shoulder 114 joining parts

112 and 113. Surface portion 111 is again frustoconical, tapering upwardly and inwardly.

In this embodiment, seal ring 116 is of the same general configuration as ring 16, Figures
70 1-6, but comprises a lower or leading portion 116a and an upper or trailing portion 116b, the two portions being rigidly interconnected in any suitable fashion. In the initial undistorted state of ring 116, the two portions
75 116a, 116b combine to present an outer surface 117 which is right cylindrical and of a diameter only slightly smaller than that of part 112 of surface portion 111, and a frustoconical inner surface 118 which tapers upwardly
80 and inwardly at the same angle as does surface portion 111. Upper portion 116b of the seal ring has a transverse annular outwardly opening groove accommodating a circular series of arcuate latch segments 130 which
85 are spring urged outwardly and can be constructed and arranged as described in detail in U.S. Pat No 4,290,483. Body 102 is provided with a transverse annular inwardly opening
90 locking groove 131 at the upper end of part 112 of surface portion 110, to receive segments 130 when the seal ring has been forced downwardly to its final active position. The upper end of portion 116b of the seal ring has a transverse annular downwardly
95 facing shoulder 120, to cooperate with a handling and retrieving tool (not shown) and an upwardly directed flat transverse annular end face 122.

Initial downward insert of seal ring 116 into
100 the annular space defined by surface portions 110 and 111 is accomplished with a handling string and tool (not shown) in the manner referred to with reference to Figures 1-6, leaving the ring in an initial position similar to that shown in Figure 5, with portion 116a of the ring being as yet undeformed and with latch segments 130 still above groove 131 and bearing on the bore wall of the casing head body. In this embodiment, downward force is
110 applied to the seal ring to accomplish final insertion by the tool indicated generally at 150. Tool 150 includes a main body 152 which is lowered by a handling string (not shown) and latched against upward movement
115 relative to body 102, as by segments 152 which are constructed and arranged as described in U.S. Patent number 4,290,483 to coact with a locking groove presented by body 102. An annular skirt 153 depends from body 151 and has a stationary seal ring 154
120 secured to the inner surface thereof coacting with skirt 153 and seal ring 154 is an annular piston indicated generally at 155 and presenting an upper outer surface portion 156, spaced inwardly from the skirt and slidably embraced by ring 154, and a lower outer surface portion 157 which is slidably embraced by the inner surface of the skirt below ring 154. An additional seal ring 158 is secured to
125 and embraces the upper end portion of the

piston and is slidably embraced by the surrounding portion of the skirt. O-rings or other suitable seals are provided, as shown, so that skirt 153 and piston 155 coact to define an upper expansible chamber 159 and a lower expansible chamber 160, suitable ducting (not shown) being provided for supply of pressure fluid selectively to the two expansible chambers. Supply of pressure fluid to chamber 159 drives piston 155 upwardly relative to tool body 151. Supply of pressure fluid to chamber 160 drives the piston downwardly, to the position shown in Figure 7.

The lower end of piston 155 has a flat transverse annular downwardly directed end face 161 dimensioned to come into flush engagement with upper end face 122 of ring 116 as the piston moves downwardly. The dimensions of ring 116 and piston 155 are such that, when ring 116 is in its preliminarily inserted position, end face 161 of the piston comes into engagement with upper end face 122 of the seal ring before the downward stroke of the piston has been completed. The total excursion of the piston is such that completion of the downward stroke of the piston forces the seal ring downwardly to the fully inserted position shown in Figure 7 and thereby results in cold-flow distortion of the lower portion 116a of the seal ring to the condition shown, that portion of the seal ring thus being in metal-to-metal sealing engagement with both surface portion 111 and part 113 of surface portion 110.

35

CLAIMS

1. A method of providing fluid tight seal across an annulus between two concentric rigid well members in order to seal the annulus against large fluid pressures said well being respectively a surface casing head or spool and a casing hanger or being a surface casing head or spool and a tubing hanger, said method comprising

45 providing concentrically opposed surface portions on the rigid members,

at least one of said surface portions being generally frustoconical and tapering longitudinally of the rigid members, whereby said surface portions define therebetween an elongate annular space which tapers from a first larger radial width to a second smaller radial width; preliminarily inserting into said annular space a metal sealing ring which has a radial thickness which decreases axially of the ring,

the direction of preliminary insertion being such that the end portion of the ring which is of smaller radial thickness enters the portion of said annular space which is of larger width and proceeds toward the portion of said annular space of smaller radial width,

said concentrically opposed surface portions each including an elongate sealing surface which extends from the end of said annular space which is of small radial width toward

the opposite end of said annular space, the length of said sealing surfaces being equal to a substantial portion of the axial length of the ring,

70 the relative radial widths of the ring and said elongate annular space being such that, as the ring is preliminarily inserted, the ring is stopped by engagement with at least one of said concentrically opposed surface portions when the leading end of the ring is still a substantial distance from the end of said elongate annular space which is of smaller radial width,

at least the leading portion of the sealing ring being of a metal capable of significant plastic deformation; and

80 while restraining the two rigid members against axial displacement, applying to the end of the ring which is of larger radial thickness a force directed axially of the ring toward the end of smaller radial thickness and substantially uniformly distributed over the annular extent of the ring and thereby forcing the metal of at least the leading portion of the ring into a condition of plastic flow, with the ring then moving further into said annular space under the action of said force until a substantial part of the length of the ring is in fluid-tight sealing engagement with both of said sealing surfaces.

2. The method defined in Claim 1, wherein one of said surface portions is interrupted by a transverse annular shoulder directed toward the end of said annular space which is of smaller radial width, the radial width of said annular space thus being increased adjacent to said shoulder on the side of the shoulder directed toward the end of smaller radial width; said step of applying force to said end of the ring causing the material of the ring to flow around said shoulder and to fill said portion of said annular space of increased width adjacent to said shoulder.

3. The method defined in Claim 2, wherein the one of said surface portions carried by the inner rigid member is frustoconical; and the one of said surface portions carried by the outer rigid member includes a first part which is right cylindrical and of smaller diameter and a second part which is right cylindrical and of larger diameter, said shoulder joining said first and second parts and said second part extending from said shoulder toward the end of said annular space of smaller radial width.

4. The method defined in Claim 1, wherein the sealing ring is of low carbon steel in the annealed or normalised state.

5. The method defined in Claim 1, wherein a portion of the sealing ring which trails during the step of inserting the ring into said annular space has means establishing preliminary seals between the ring and the opposed surface portions during the step of preliminarily inserting the sealing ring into said annular space;

130

and

the step of applying the large force to the sealing ring is accomplished by supplying fluid under pressure at the end of the ring of larger radial thickness.

6. A surface well apparatus comprising a first rigid member having a bore including an inwardly facing annular surface portion, said first member comprising a surface casing head or spool, a second rigid member extending within said bore and having an outer surface spaced inwardly from said bore wall to provide an annulus between the first and second rigid members, said outer surface including an outwardly facing surface portion spaced inwardly from and concentric with said inwardly facing surface portion, said second member comprising a casing hanger or a tubing hanger, at least one of said inwardly facing annular surface portion and said outwardly facing surface portion being generally frustoconical and tapering longitudinally of said rigid members, whereby said inwardly facing and outwardly facing surface portions combine to define an annular space which tapers from a first larger radial width to a second smaller radial width,

one of said inwardly facing and outwardly facing surface portions being interrupted by a transverse annular shoulder directed toward the end of said annular space which is of smaller radial width, the radial width of said annular space thus being increased adjacent said shoulder on the side of the shoulder toward the end of small radial width; and a metal sealing ring disposed in said annular space and comprising

a first end portion at the end of said annular space which is of smaller radial width, said first end portion of the sealing ring substantially completely filling the corresponding portion of said annular space and having an outer surface in sealing engagement with the corresponding part of said inwardly facing surface portion of said first rigid member and an inner surface in sealing engagement with the corresponding part of said outwardly facing surface portion.

7. Surface well apparatus as defined in Claim 6, wherein the sealing ring comprises a second end portion exposed at the corresponding end of said annular space; and further comprises stop means carried by one of said rigid members and co-acting with said second end portion of the sealing ring to restrain the sealing ring against axial movement in a direction toward the end of said annular space which is of larger radial width.

8. Surface well apparatus as defined in Claim 7 wherein said outwardly facing surface portion is frustoconical; and said inwardly facing surface portion is right-cylindrical.

9. Surface well apparatus as defined in Claim 8, wherein said inwardly facing surface portion includes a first part which is of smaller

diameter and is opposed to that portion of the outwardly facing surface portion adjacent to the end of said annular space which is of larger radial width, and a second part which is of larger diameter and is opposed to that portion of the outwardly facing surface portion adjacent to the end of said of said annular space which is of smaller radial width, said first and second parts of said inwardly facing surface portion being joined by said transverse annular shoulder.

10. Surface well apparatus as defined in Claim 6, wherein the portion of the sealing ring which extends beyond said shoulder toward the end of said annular space which is of smaller radial width is of ductile metal and is in flush sealing engagement with said shoulder and portions of said inwardly facing surface and said outwardly facing surface extending from said shoulder toward the end of said annular space which is of smaller radial width.

11. Surface well apparatus as defined in Claim 6, wherein the sealing ring is provided with inner and outer elastomeric seals in locations spaced from said end portion of the ring toward said second portion of the ring, the dimensions of the ring being such that, when the ring has been preliminarily inserted into said annular space, said elastomeric seals will respectively engage said outwardly facing surface portion and said inwardly facing surface portion, whereby fluid under pressure can be applied against said second end portion of the ring to drive the ring into said annular space.

12. Surface well apparatus as defined in Claim 6, wherein the first rigid member includes a transverse annular inwardly opening locking groove spaced axially from said inwardly facing surface portion; and said lock means comprises a lock ring engaged in said groove and bearing against said second end portion of the ring.

13. Surface well apparatus comprising a rigidly supported surface casing head having an upright bore, said bore including an upper right cylindrical wall portion, a lower right cylindrical wall portion, and a transverse annular downwardly facing shoulder joining said wall portions;

a second body disposed within said bore and including a frustoconical outer surface portion concentric with and spaced inwardly from said cylindrical wall portions, said outer surface portion tapering upwardly and inwardly, whereby said cylindrical wall portions and said outer surface portion combine to define an annular space which tapers from an upper end of larger radial width to a lower end of smaller radial width, said second body comprising a casing hanger or a tubing hanger, said second body being rigidly supported against downward movement relative to said outer body;

a metal seal ring disposed between said cylindrical wall portions and said outer surface

portion, the radial thickness of said seal ring decreasing from the upper end of the lower end of the ring, a lower portion of said seal ring being plastically deformed into direct

- 5 metal-to-metal sealing engagement with both said cylindrical wall portions and said outer surface portion; and
stop means engaged with said seal ring and said surface casing head to restrain said seal
10 ring against upward movement relative to said surface casing head.

14. A method of providing a fluid tight seal across an annulus between two concentric rigid well members in order to seal the annulus
15 against large fluid pressures said well members being respectively a surface casing head or spool and a casing hanger or being a surface casing head or spool and a tubing hanger, substantially as hereinbefore described
20 with reference to the accompanying drawings.

15. Surface well apparatus substantially as hereinbefore described with reference to the accompanying drawings.

16. The features hereinbefore disclosed or
25 their equivalents, in any novel selection.

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